How Past Research has Informed Decision-Making on Columbia River Estuary Restoration and Future Research Needs

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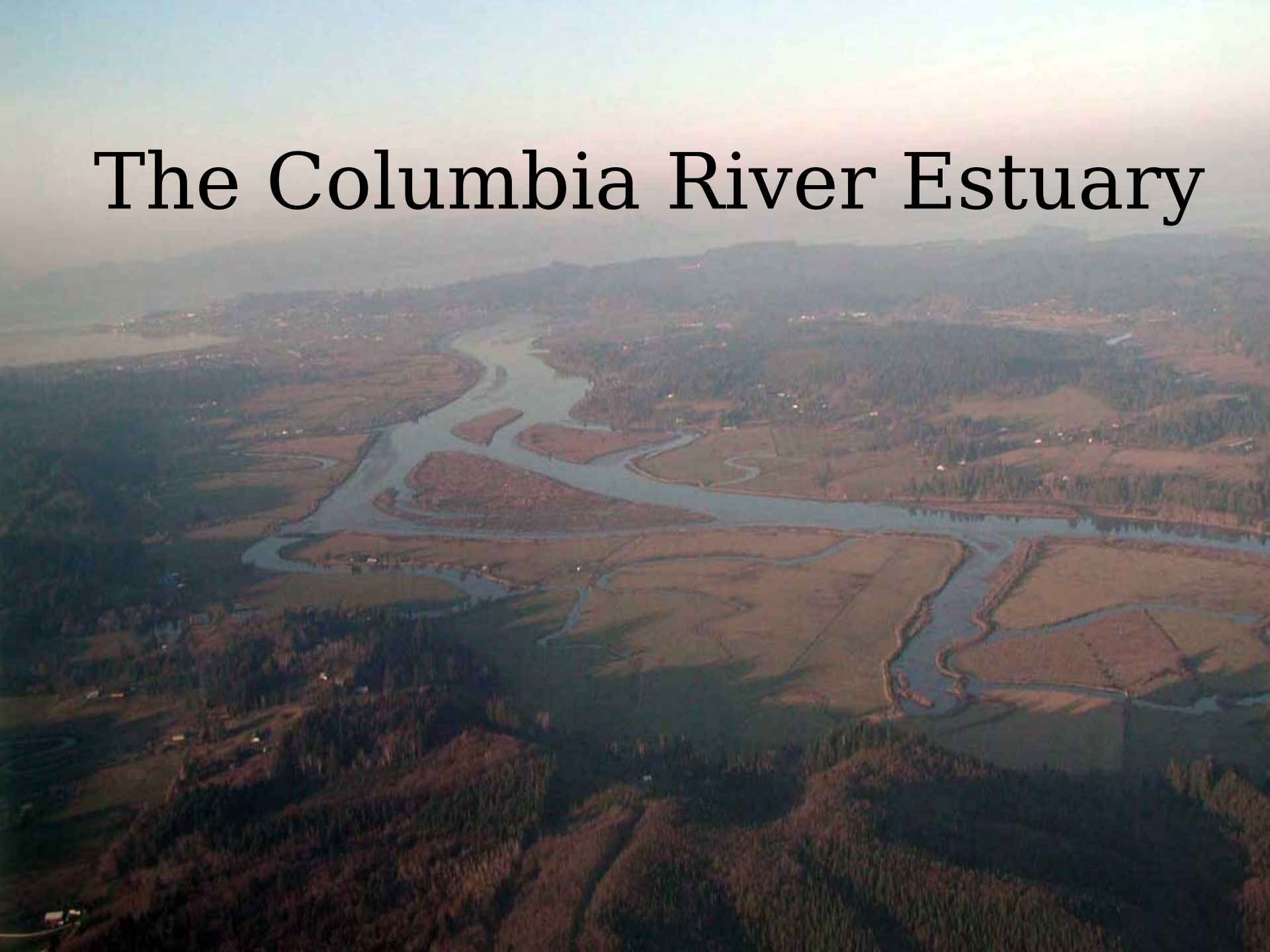
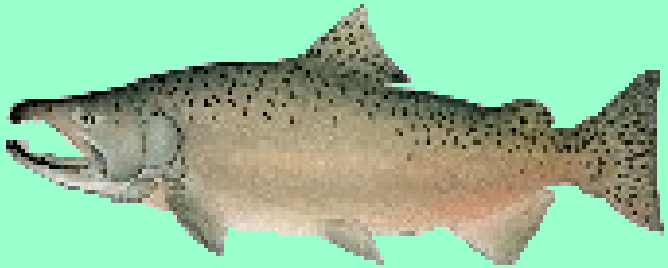
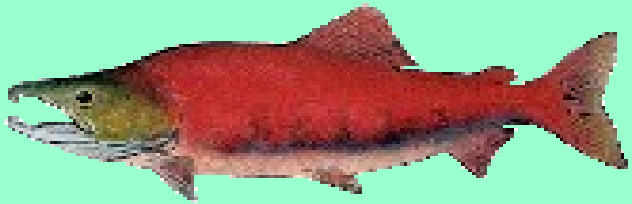
The Columbia River Estuary



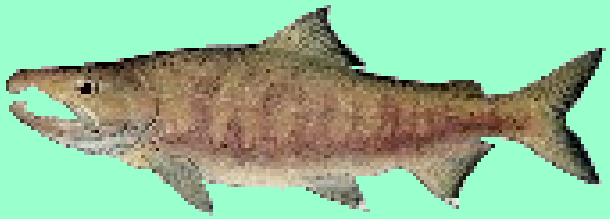
Columbia River Basin Salmonids



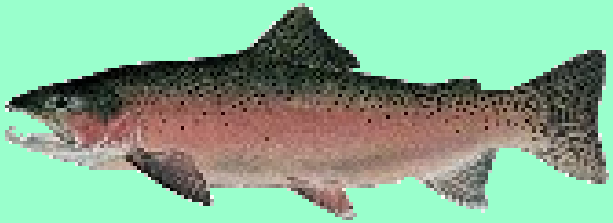
Chinook salmon



Sockeye salmon



Chum salmon



Steelhead trout

Salmonid Life-History

Ocean-Type

L. Col. Riv. Chinook
U.Col. Riv. spring-run Chinook
U. Will. Riv. Chinook
Snake Riv. Fall Chinook
Chum

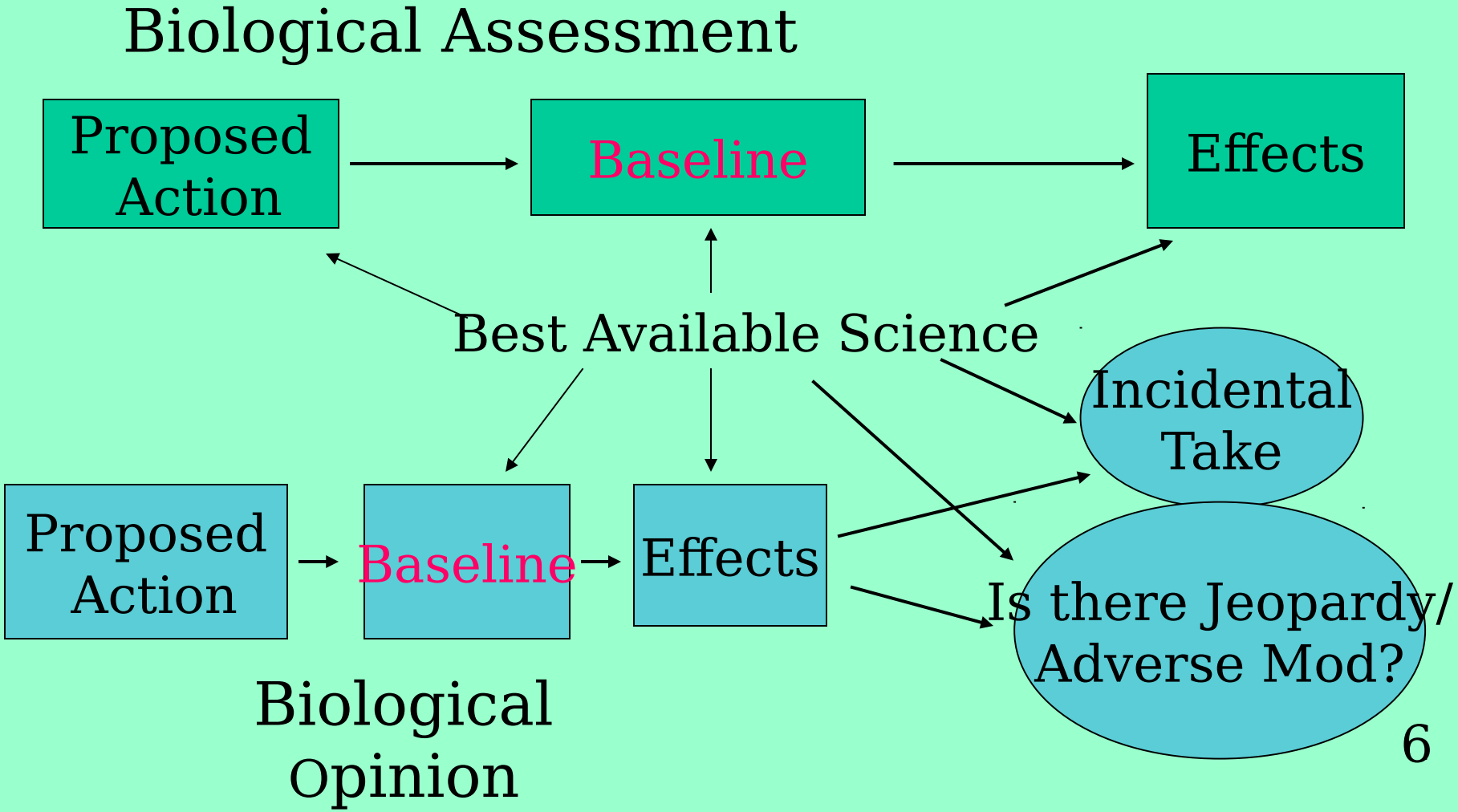
Stream-Type

L. Col. Riv. Chinook
U. Will. Riv. Chinook
Snake Riv. Fall Chinook
U. Col. Riv. Steelhead
L. Col. Riv. Steelhead
M. Col. Riv. Steelhead
Snake Riv. Basin Steelhead
Snake Riv. Sockeye

The Endangered Species Act

Provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved

Endangered Species Act Consultation Process



FCRPS 2000 Biological Opinion

Reinitiation of Consultation on Operation of the **Federal Columbia River Power System**, Including the Juvenile Fish Transport Program, and 19 Bureau of Reclamation Projects in the Columbia Basin

December 21, 2000

FCRPS 2000 Biological Opinion

- Three Action Agencies – Bonneville Power Administration, Corps of Engineers, and Bureau of Reclamation
- Requires the action agencies to avoid Jeopardy to the 12 Columbia Basin Listed Salmon and Steelhead species
- Requirements include improvements in mainstem survival

FCRPS 2000 Biological Opinion

Requirements include **off-site mitigation** that should improve salmon survival as a result of hatchery, harvest, and

Habitat Actions

FCRPS Biological Opinion RPA Estuary Actions

- **158** - develop an action plan to inventory estuarine habitat and develop criteria for habitat restoration
- **159** - develop a plan addressing the needs of salmon and steelhead in the estuary
- **160** - develop and implement an estuary restoration program with the goal of protecting and enhancing 10,000 acres of tidal wetlands and other key habitats

FCRPS Biological Opinion RPA Estuary Actions

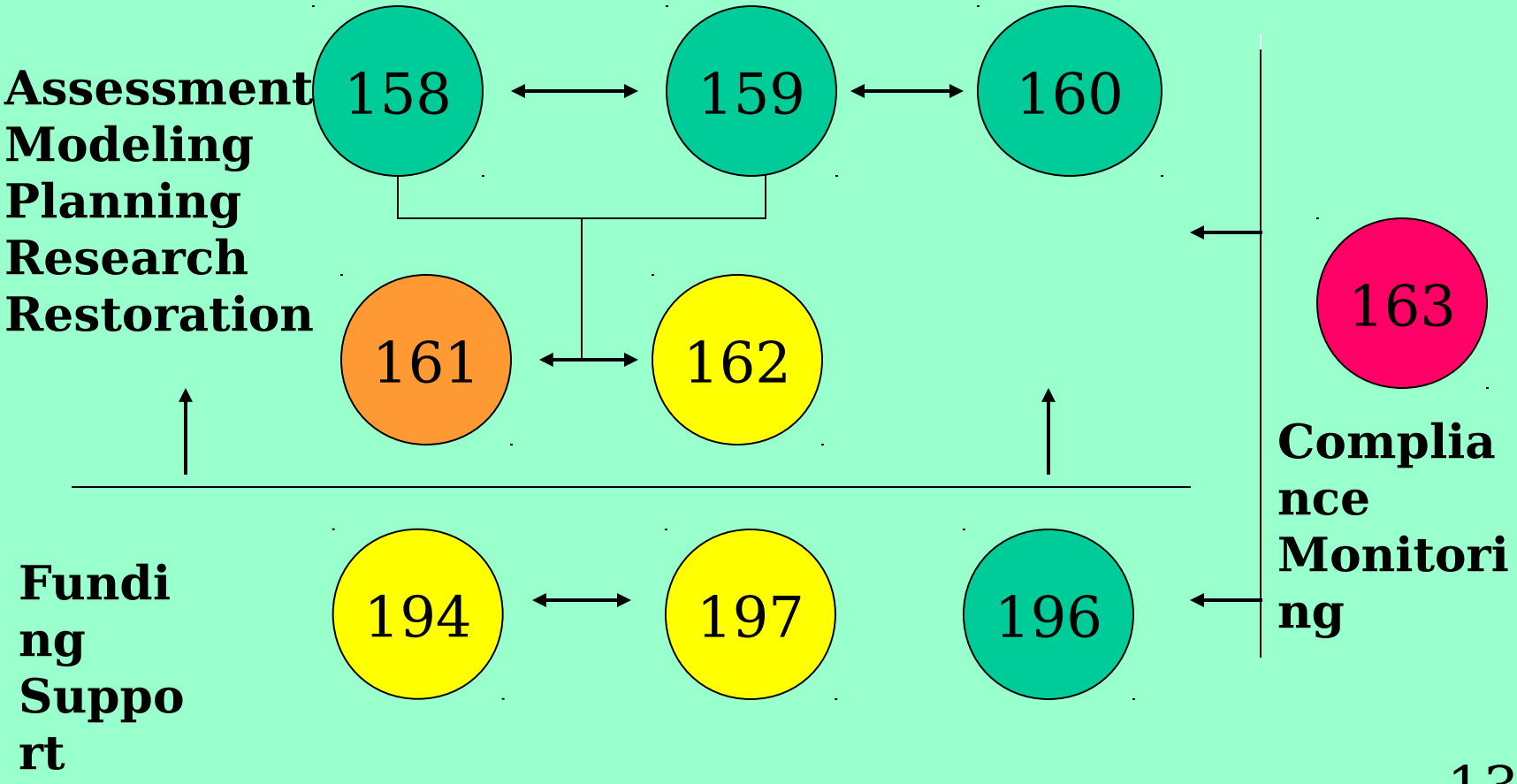
- **161** - Fund a monitoring and research program acceptable to NMFS
- **162** - Develop a conceptual model of the relationship between estuarine conditions and salmon population resilience
- **194** - Provide the appropriate level of FCRPS funding for studies to develop a physical model of the Lower Columbia River and plume

FCRPS Biological Opinion RPA Estuary Actions

- **196** - Provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River estuary

- **197** - Provide the appropriate level of FCRPS funding for studies to develop an understanding of juvenile and adult salmon use of the Columbia River plume

2000 FCRPS BIOP: Relationship of Estuary/Plume Actions



What do We know About Lower Columbia River and Estuary Habitats?

- **Columbia River Estuary Data Development Program** (Columbia River Estuary Study Taskforce)
- **Historic Habitats of the Lower Columbia River** (Columbia River Estuary Study Taskforce)
- **Floodplain Habitat Cover Types of the Lower Columbia River and Estuary** (Lower Columbia River Estuary Partnership)
- **Salmon at the River's End** (NOAA Fisheries)

Columbia River Estuary Data Development Program
(The CREDDP Study)

The CREDDP studies during 1979-1980 provided the first real estimates of fundamental estuarine processes.

- “Changes in Columbia River Estuary Habitat Types Over the Past Century”

The CREDDP Study
Topics Covered

- Examined sediment accretion (shoaling), productivity, and trophic structure Estuary scale circulation patterns
- Assessed effects of historical change on the estuarine ecosystem
- Examined juvenile salmon usage of the estuary below the tidal freshwater reaches of the Lower Columbia River
- Quantified organic matter through the estuarine food web

The Main Messages from the CREDDP Study

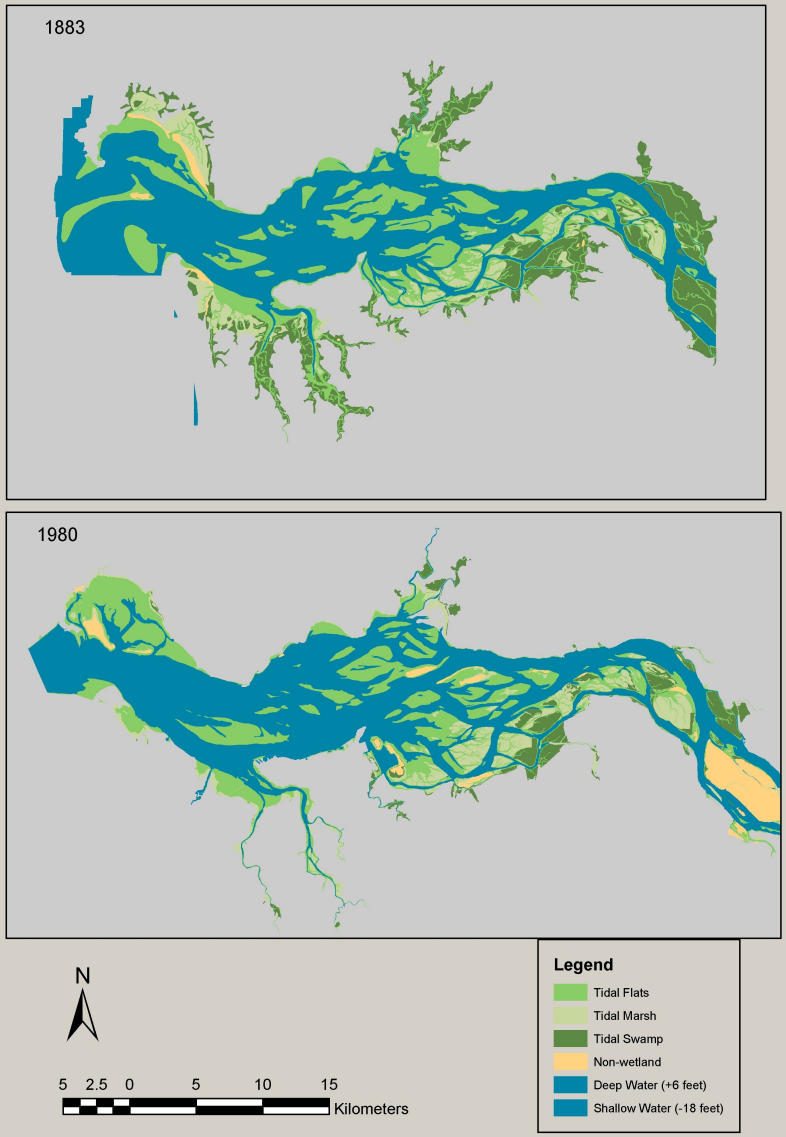
- Most loss and degradation of habitat within the Columbia River estuary occurred after the 1800s.

- Following a century of diking and filling activity, only 35% of the former area of marsh and swamp habitat remained in the estuary after 1980.

Historic Change in Columbia River Estuary, 1883-1980

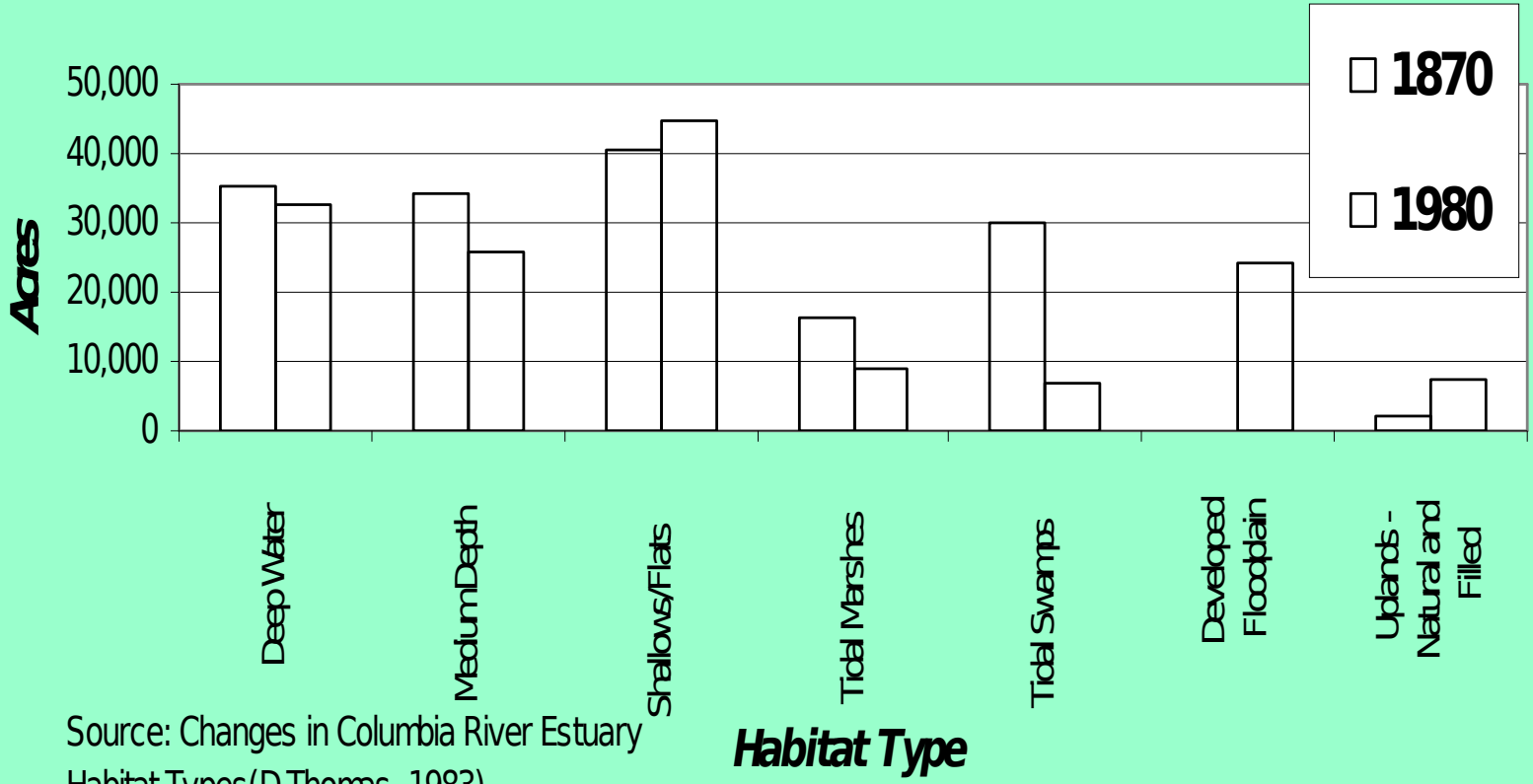
Habitat changes:

- **Diking for agriculture and shoreline development**
- **Loss of structural complexity via channelization and development**
- **Loss in productive capacity of ecosystem**



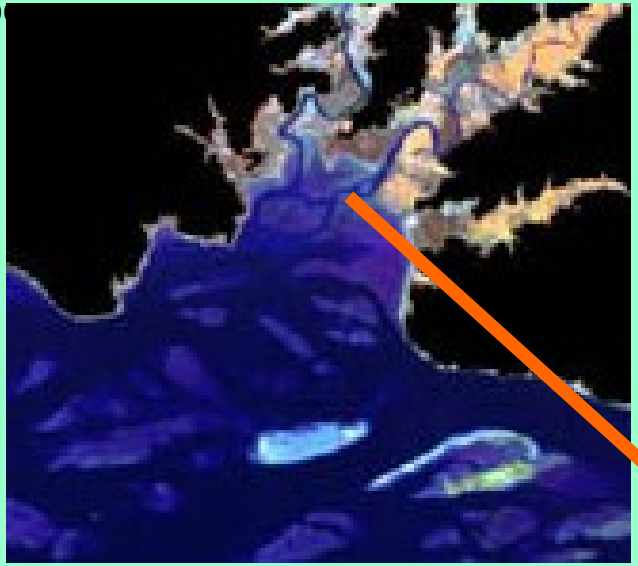
Source: J. Burke, OSU modification of Thomas (1883)

Historic Habitat Type Changes 1870-1980 Lower Columbia River (mouth to RM 46)



Source: Changes in Columbia River Estuary Habitat Types (D.Thomas, 1983)

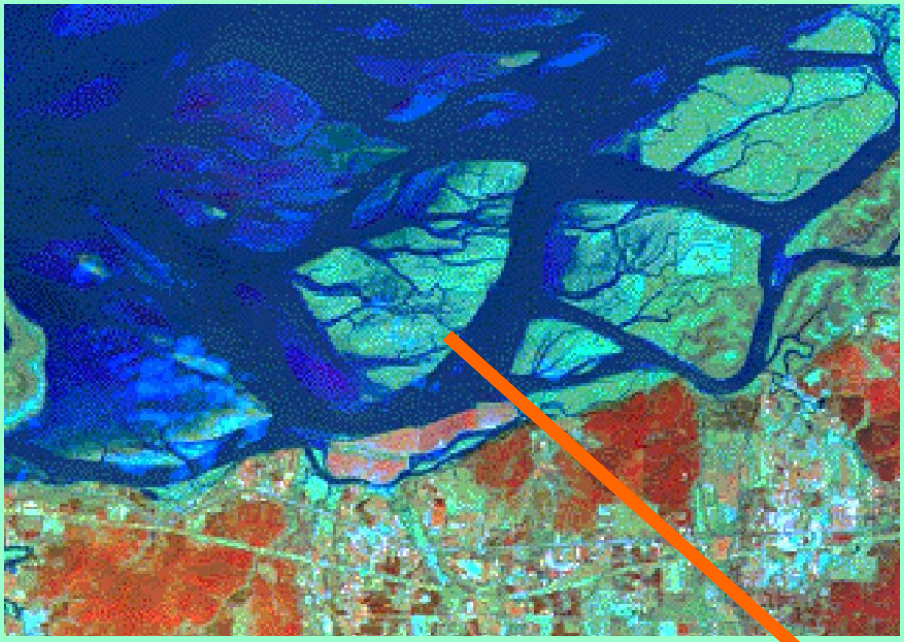
LANDSAT7 TM image from LCREP, Earth Design Consultants and University of Washington-Wetland Ecosystem Team studies, 2000-20



TIDAL FLATS AND OPEN WATER

Photo by R. Emmett, NMFS

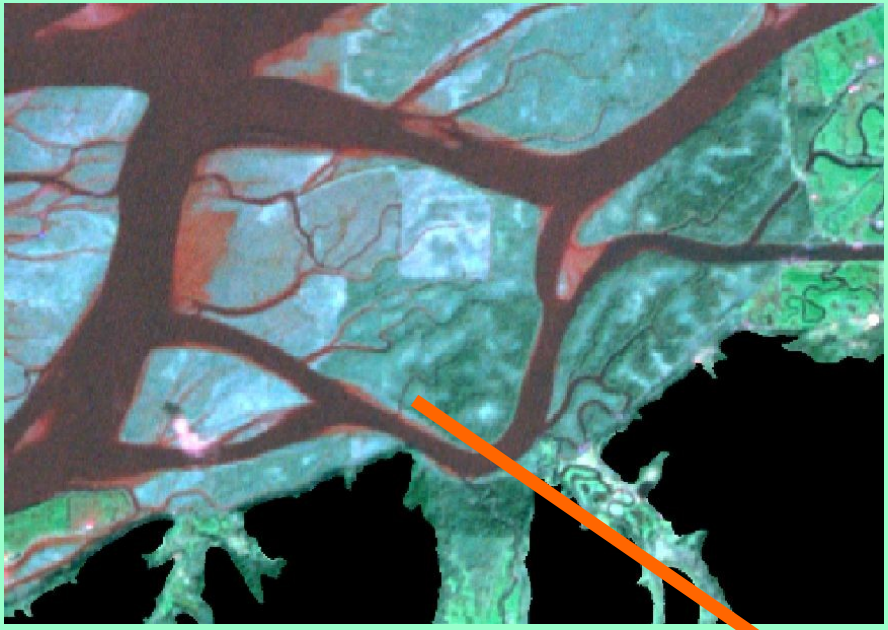
Grays Bay (foreground), and Columbia River Estuary



TIDAL MARSHES

Russian Island Marsh, Cathlamet Bay, Columbia River Estuary

Photo by C. Simenstad, Univ. Washington

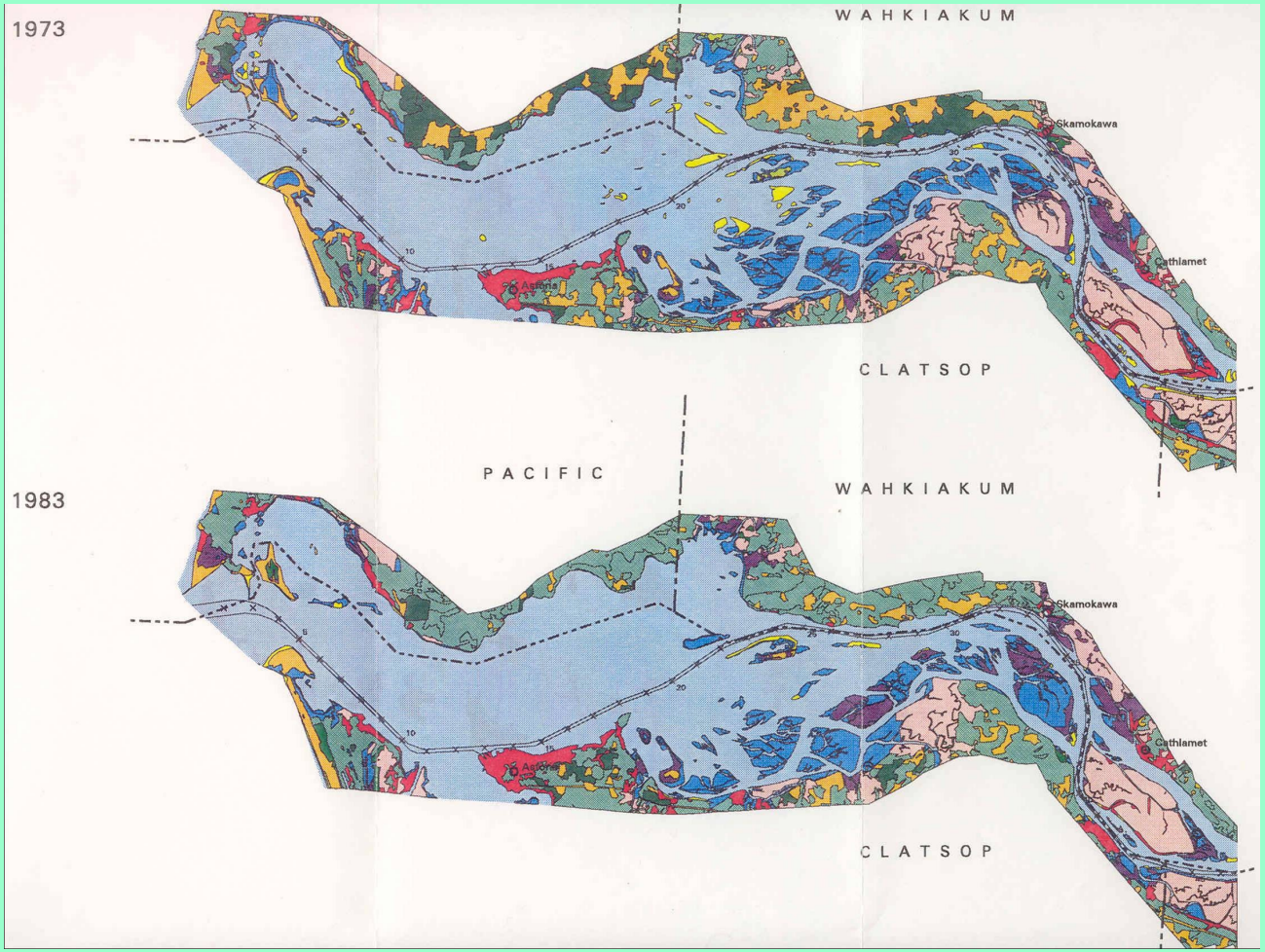


TIDAL SWAMPS

Karlson Island Tidal Freshwater Wetland Slough, Cathlamet Bay, Columbia River Estuary

Historic Habitats of the Lower Columbia River

(Crest 1995)



Historic Habitats of the Lower Columbia River

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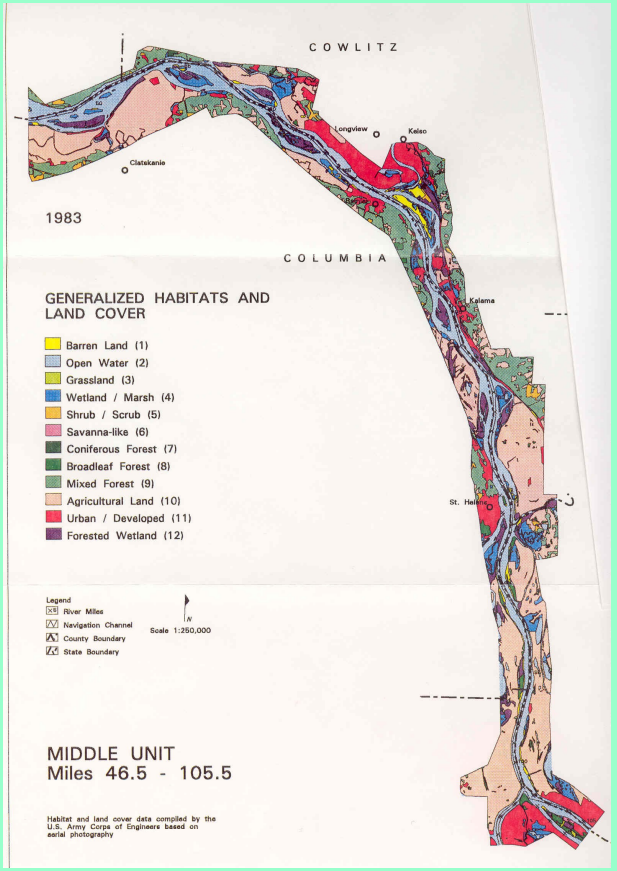
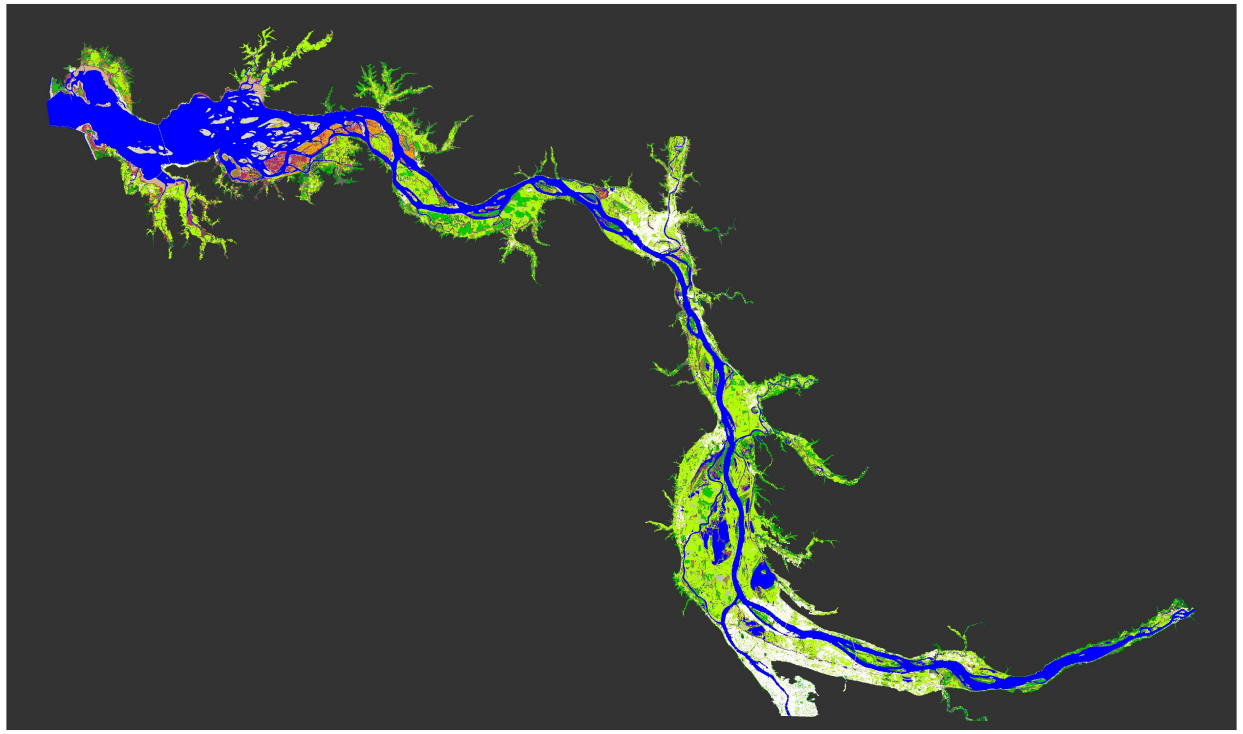


Floodplain Habitat Cover Types of the Lower Columbia Rover and Estuary

(LCREP December 2002)



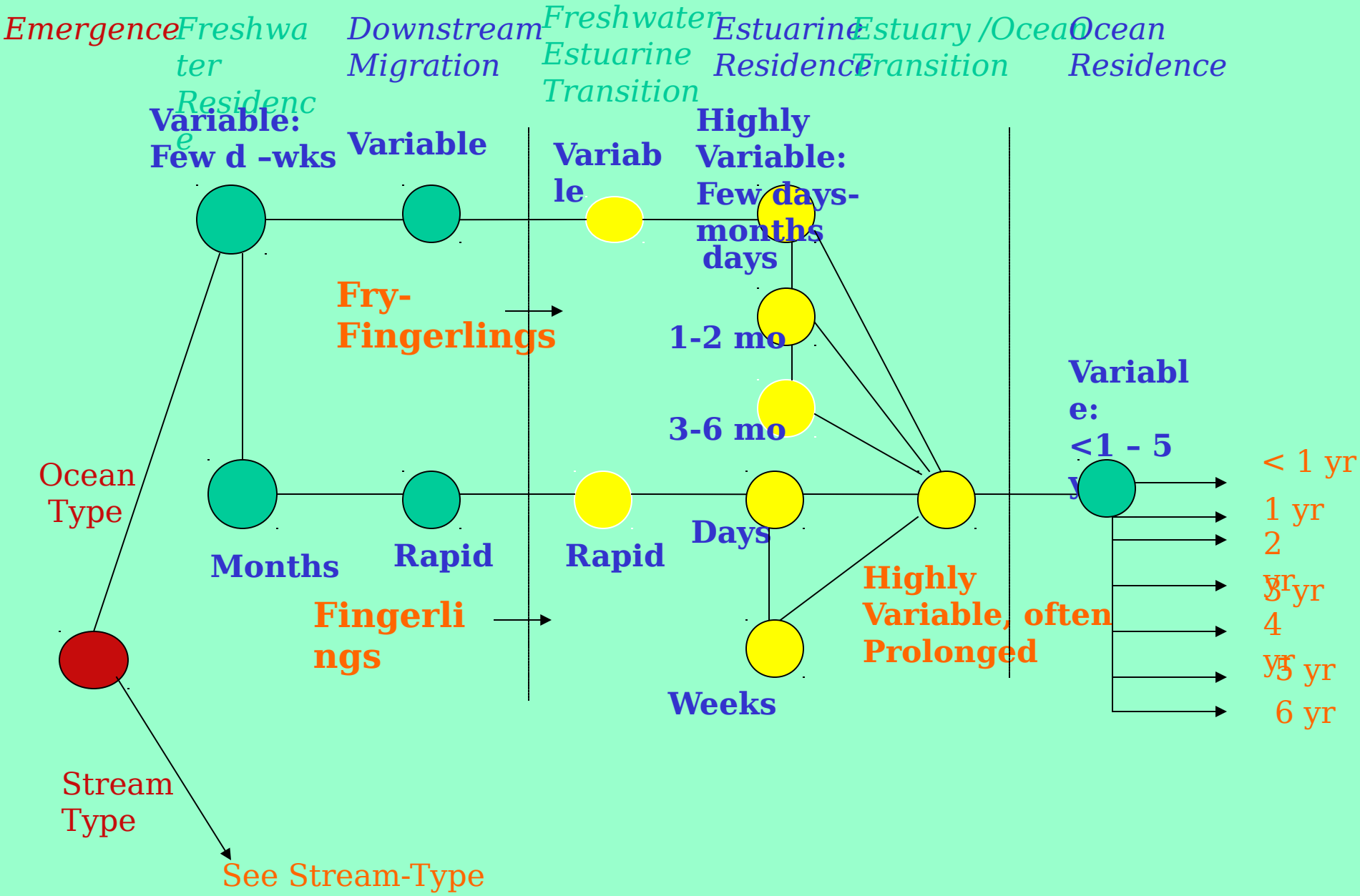
Salmon At River's End: The Role of the Estuary in the Decline of Columbia River Salmon (SARE)

- Report evaluated the following six aspects of the Columbia River estuary
  - Estuarine Development History and Salmon Decline
  - Conceptual Framework for Evaluating Estuarine Habitat Conditions
  - Change in Hydrologic Conditions
  - Estuarine Habitat Opportunity
  - Estuarine Habitat Capacity
  - Change in Juvenile Salmon Life History, Growth, and Estuarine Residence

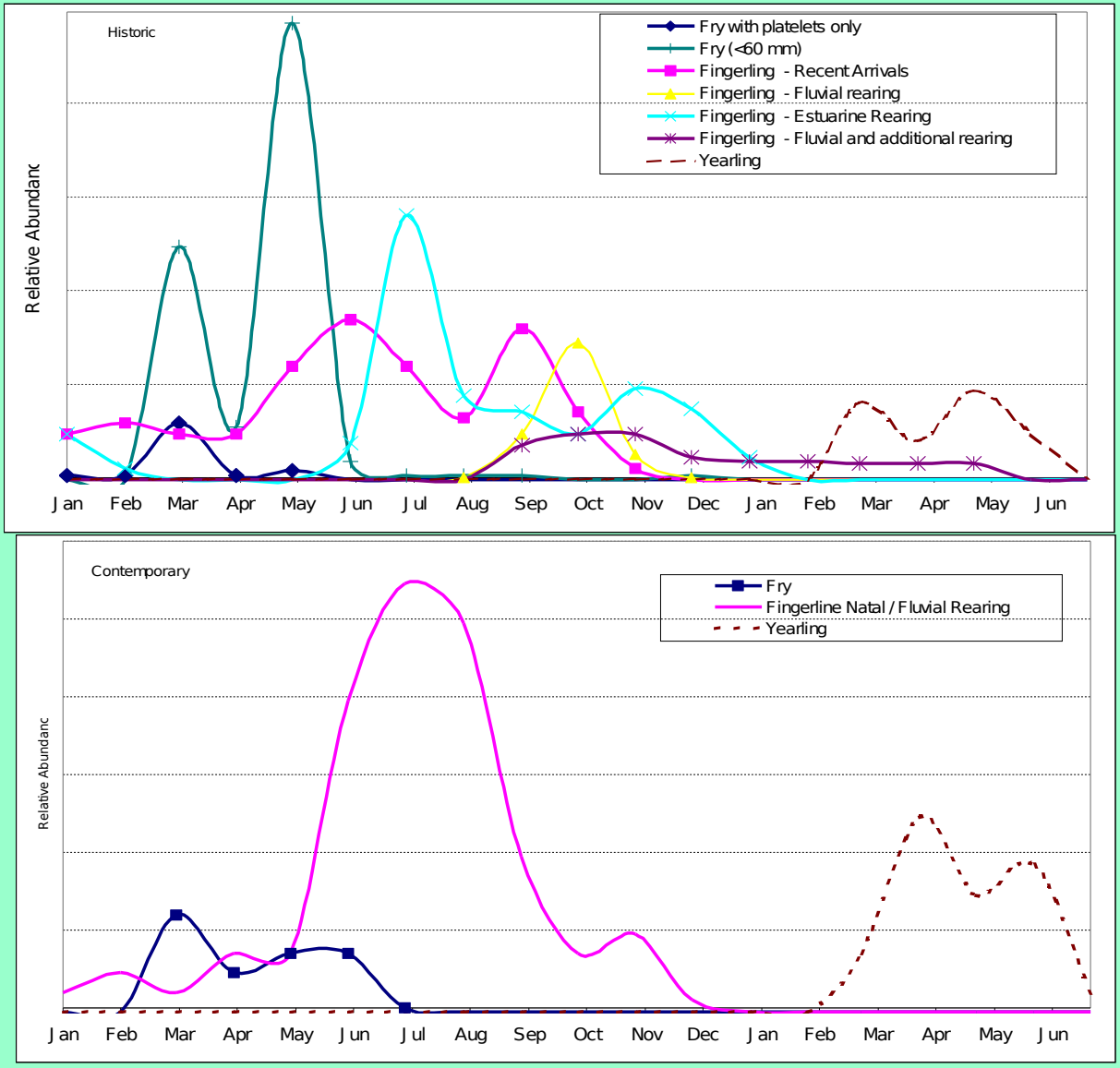
Key Assumption of the SARE Report

Resilience of Columbia River salmon to natural environmental variability is embodied in population and life-history diversity, which maximizes the ability of populations to exploit estuarine rearing habitats.

Chinook Salmon Ocean-Type



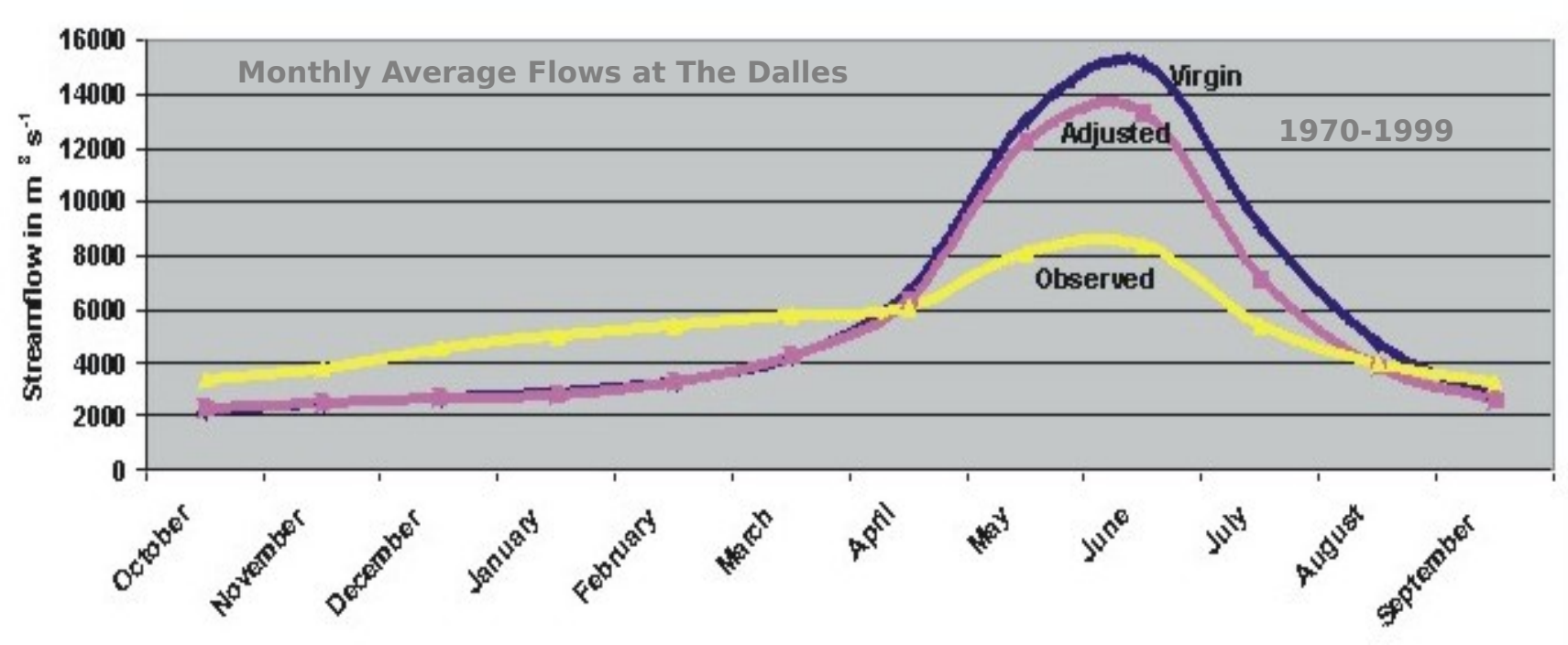
Historic vs. Contemporary Life History


Historic
Fry with platelets only
Fry (<60 mm)
Fingerling - Recent Arrivals
Fingerling - Fluvial rearing
Fingerling - Estuarine Rearing
Fingerling - Fluvial and additional rearing
Yearling
Relative Abundanc
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
Contemporary
Fry
Fingerline Natal / Fluvial Rearing
Yearling
Relative Abundanc
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun

One-brood year of chinook salmon in the Columbia River estuary

Rich (1920)
Dawley et al. (1985)

Effects of Flow Regulation

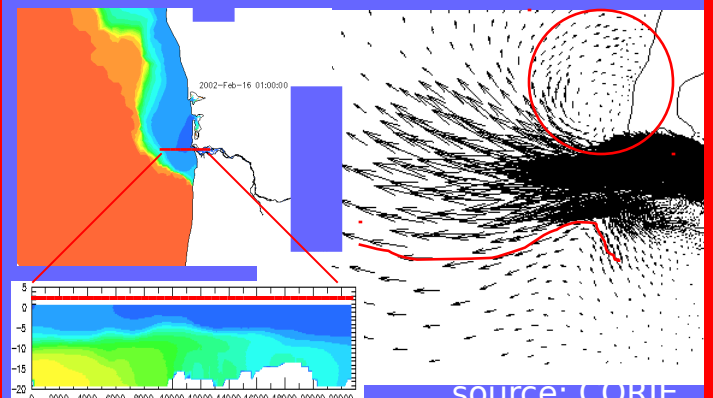


<u>Reduced</u> peak freshet flow by >40%

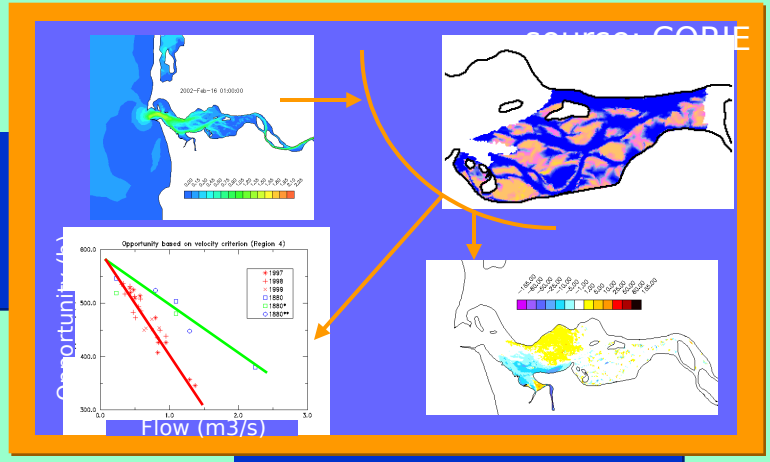
<u>Reduced</u> freshet season flow by ~30%

Freshet longer and peak flow <u>earlier</u> due to pre-release

Greatly <u>increases</u> fall-winter minimum flows



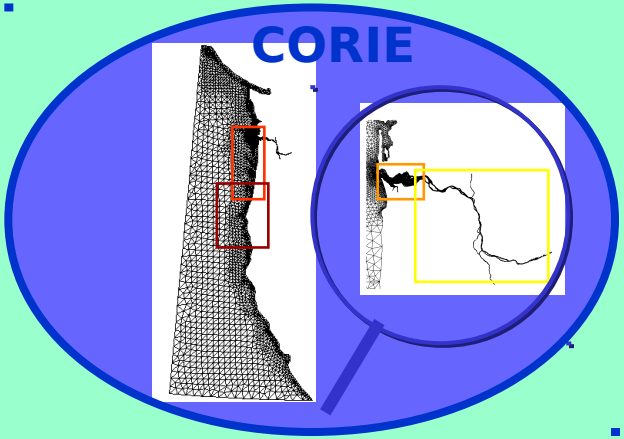
ocean/estuary connectivity



Physical Habitat Opportunity

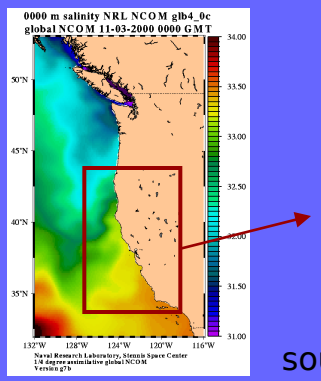
Extent, persistency, and connectivity of trapping regions/features:

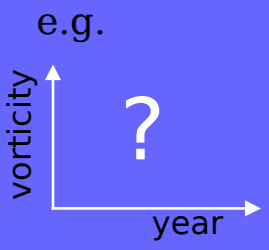
- plume
- eddies
- shear fronts
- salinity fronts
- ...



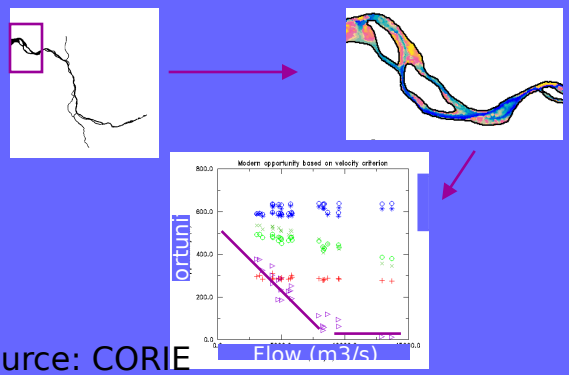
Physical Habitat Opportunity

- Water depth
  - $0.1m \leq D \leq 2m$
- Water velocity
  - $v \leq 30$ cm/s
- Salinity
  - $s \leq 5$ psu
- Temperature

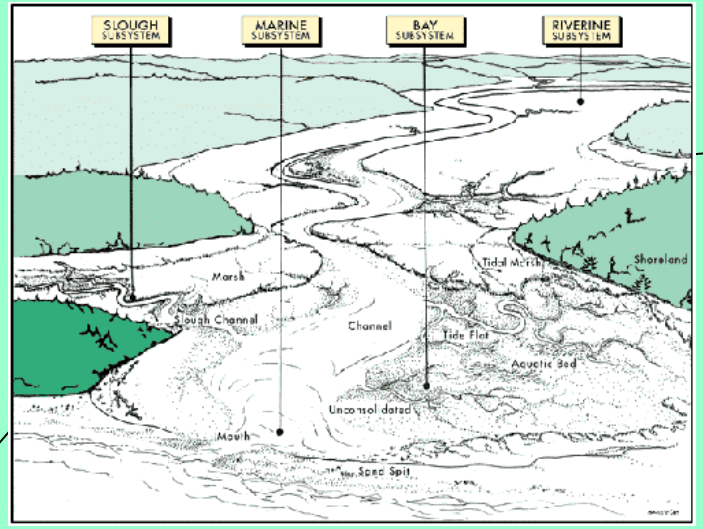




source: NRL → CORIE

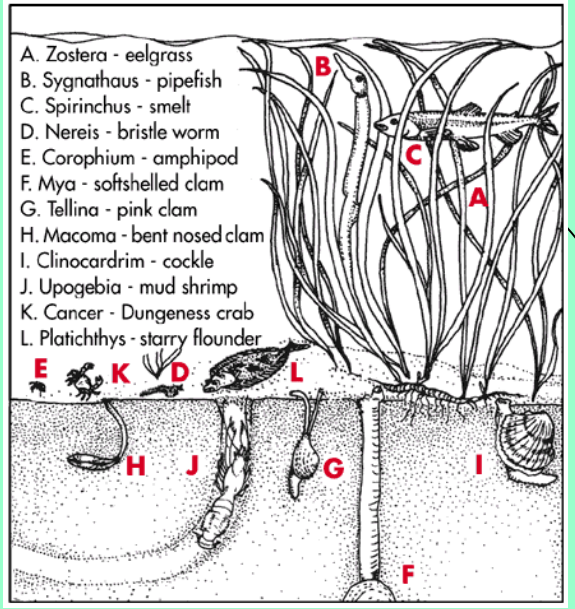


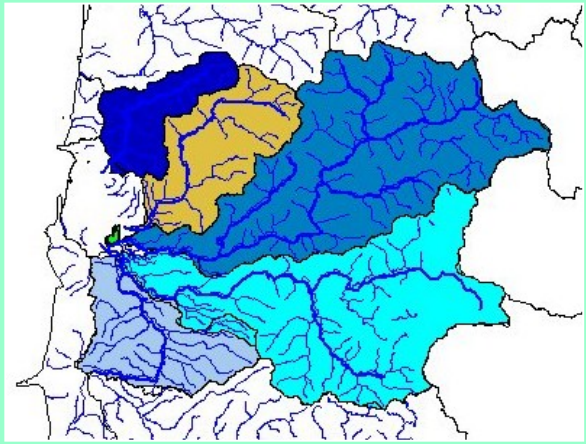
source: CORIE



Habitat Opportunity

- Dikes, tide gates
- Elevation
- Velocity, etc.


A. Zostera - eelgrass
B. Sygnathaus - pipefish
C. Spirinchus - smelt
D. Nereis - bristle worm
E. Corophium - amphipod
F. Mya - softshelled clam
G. Tellina - pink clam
H. Macoma - bent nosed clam
I. Clinocardrim - cockle
J. Upogebia - mud shrimp
K. Cancer - Dungeness crab
L. Platichthys - starry flounder



Habitat Capacity (Quality)

- Prey resources
- Habitat structure (refugia)
- Temperature, etc.

Population Structure (Life History)

- Harvest
- Hatcheries
- Upstream habitat

Performanc

- Growth
- Survival
- Variance, etc.

Recommended Actions for Estuary Restoration

- **RESTORATION NEEDS**
  - Protect and restore salmon access forested wetlands and tidal floodplains
  - Expand the phenotypic diversity of salmon

Research Approach for the Columbia River Estuary

Reconstruct **historic changes in estuarine rearing opportunities and food-web linkages** of Columbia River salmon and evaluate their implications for **managing river flows and restoring estuarine habitats**

Recommended Actions for Estuary Monitoring

- **MONITORING NEEDS**
  - Monitor, on a long-term basis, the variations in juvenile salmon life-history diversity, habitat use, and performance in the estuary
  - Develop the necessary tools to house, manage, and disseminate the data and information

Programmatic Approach For Actions in the Lower Columbia River, Estuary, and Ocean